

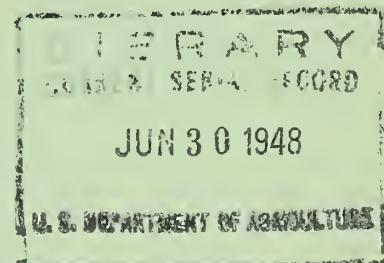
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# CONQUEST OF THE LAND *through* *Seven Thousand Years.*



U.S. DEPARTMENT OF AGRICULTURE  
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## FOREWORD

In 1938 and 1939, Dr. W. C. Lowdermilk, who was an assistant chief of the U. S. Soil Conservation Service at that time, made an 18-month tour of western Europe, North Africa, and the Middle East to study soil erosion and land use in those areas. This tour was sponsored by the Soil Conservation Service at the request of a congressional committee. The main objective of the tour was to gain information from those areas -- where some lands had been in cultivation for hundreds and thousands of years -- that might be of value in helping to solve the soil erosion and land use problems of the United States.

During the 1938-39 tour, Dr. Lowdermilk visited England, Holland, France, Italy, Algeria, Tunisia, Tripoli, Egypt, Palestine, Trans-Jordan, Lebanon, Cyprus, Syria, and Iraq. Prior to that time, he had spent several years in China where he had studied soil erosion and land use problems.

After his return to this country, Dr. Lowdermilk gave numerous lectures, illustrated with lantern slides, about his findings on land use in the old world. "Conquest of the Land through Seven Thousand Years" is the essence of those talks. It was first published in 1942, in mimeograph form, as a lecture. It has been used extensively in conjunction with lantern slides by many school teachers and other lecturers. It proved to be so popular that it now has been slightly revised and illustrated, and is published in its present form with the hope that its usefulness will be greatly extended.

Most of the illustrations used in this publication were made from photographs taken by Dr. Lowdermilk during his travels.

# CONQUEST OF THE LAND THROUGH SEVEN THOUSAND YEARS

By

*Walter Lowdermilk* 1888-

Some time ago I heard of an old man down on a hill farm in the South, who sat on his front porch as a newcomer to the neighborhood passed by. The newcomer to make talk said, "Mister, how does the land lie around here?" The old man replied, "Well -- I don't know about the land a-lying; it's these real estate people that do the lying." In a very real sense the land does not lie; it bears a record of what men write on it. In a larger sense a nation writes its record on the land, and a civilization writes its record on the land -- a record that is easy to read by those who understand the simple language of the land. Let us read together some of the records that have been written on the land in the westward course of civilization from the Holy Lands of the Near East to the Pacific Coast of our country through a period of some 7000 years.

Records of mankind's struggles through the ages to find a lasting adjustment to the land are found written across the landscapes as "westward the course of empire took its way." Failures are more numerous than successes, as told by ruins and wrecks of works along this amazing trail. From these failures and successes we may learn much of profit and benefit to this young nation of the United States as it occupies a new and bountiful continent and begins to set up house for a thousand or ten thousand years -- yea, for a boundless future.

## Freedom Bought and Sold for Food

Pearl Harbor, like an earthquake, shocked the American people to a realization that we are living in a dangerous world — dangerous for our way of life, for our survival as a people, and perilous for the hope of the ages in a government of the people, by the people and for the people. Why should the world be dangerous for such a philanthropic country as ours?

The world is made dangerous by the desperation of peoples suffering from privations and fear of privations, brought on by restrictions of the exchange of the good and necessary things of Mother Earth. Industrialization has wrought in the past century far reaching changes in civilization, such as will go on and on into our unknown future. Raw materials for modern industrialization are localized here and there over the globe; they are not equally available to national groups of peoples who have learned to make and use machines. Wants and needs of food and raw materials have been growing up unevenly and bringing on stresses and strains in international relations that are seized upon by ambitious peoples and leaders to control by force the sources of such food and raw materials. Wars of aggression, long and well planned, take place to obtain such materials.

Such conflicts are not settled for good by war; the problems are pushed aside for a time only to come back in more terrifying proportions at some later time. Lasting solutions will come in another way. We can depend on the reluctance of peoples to launch themselves into war, for

they go to war because they fear something worse than war, either real or propagandized. A just relation of peoples to the earth rests not on exploitation, but rather on conservation -- not on the dissipation of resources, but rather on restoration of the productive powers of the land and on access to food and raw materials. If civilization is to avoid a long decline such as has blighted North Africa and the Near East for 13 centuries and for centuries yet to come, society must be born again out of an economy of exploitation into an economy of conservation.

We are now getting down to fundamentals in this relationship of a people to the land. My experience with famines in China taught me that in the last reckoning all things are purchased with food. This is a hard saying; but the recent world-wide war shows up the terrific reach of this fateful and awful truth. Aggressor nations used the rationing of food to subjugate rebellious peoples of occupied countries. For even you and I will sell our liberty and more for food, when driven to this tragic choice. There is no substitute for food.

Seeing what we will give up for food, let us look at what food will buy -- for money is merely a symbol, a convenience in the exchange of the goods and services that we need and want. Food buys our division of labor that begets our civilization. Not until tillers of soil grew more food than they themselves required were their fellows released to do other tasks than the growing of food -- that is, to take part in a division of labor that became more complex with the advance of civilization. For the lumberjack does not go into the forest to cut and log out timber until food is made available, nor do miners dig the ore out of the bowels of mountains, nor mechanics fashion metals into tools and machines, nor soldiers fight battles until food is made abundant and adequate.

True, we have need of clothing, of shelter, of other goods and services made possible by a complex division of labor founded on this food production when suitable raw materials are at hand. And of these the genius of the American people has given us more than any other nation ever possessed. They comprise our American standard of living. But these other good things matter little to hungry people as I have seen in the terrible scourges of famine.

Food production is thus the final and fundamental measure of adjustment of a people to its land resources. Food production is the measure of the carrying capacity of the land for a human population, but the multiplicity in divisions of labor determines our standards of living. Trade and transportation permit concentration of peoples in cities and certain countries beyond the food producing capacity of the underlying land, but this in no way invalidates this basic relation of a people to the earth.

Food comes from the holy earth. The land with its waters gives us nourishment. The earth rewards richly the knowing and diligent but punishes inexorably the ignorant and slothful. This partnership of land and farmer is the rock foundation of our complex social structure.

In 1938, in the interests of a permanent agriculture and of the conservation of our land resources, the Department of Agriculture asked me to make a survey of land use in olden countries, for the benefit of our farmers and stockmen and other agriculturists in this country. This survey took us

through England, Holland, France, Italy, North Africa, and the Near East, and after 18 months was interrupted by the outbreak of war when Germany invaded Poland in September of 1939. We were prevented from continuing the survey through Turkey, the Balkan States, Southern Germany, and Switzerland as was originally planned. But in a year and a half in the olden lands we discovered many things of wide interest to the people of America.

### Graveyard of Empires

We shall begin our reading of the record as it is written on the land in the Near East, where civilization arose out of the mysteries of the Stone Age and gave rise to cultures that moved eastward to China and westward through Europe and across the Atlantic Ocean to the Americas. We are daily and hourly reminded of our debt to the Sumerian peoples of Mesopotamia, whenever we use the wheel that they invented more than 6000 years ago; we do homage to their mathematics each time we look at the clock or our watches to tell time divided into units of sixty. Moreover, our calendar in use today is a revision of the method of the ancient Egyptians in dividing the year. We inherit the experience and knowledge of the past more than we know.

Agriculture had its beginnings at least 7000 years ago and developed in two great centers -- in the fertile alluvial plains of Mesopotamia and the Nile Valley. We shall leave the interesting question of the precise area in which agriculture originated to the archaeologists. It is enough for us to know that it was in these alluvial plains in an arid climate that tillers of soil began to grow food crops by irrigation in quantities greater than their own needs and released their fellows for a division of labor that gave rise to what we call civilization. We shall follow the vicissitudes of peoples recorded on the land, as nations rose and fell in these fateful lands.

A survey of such an extensive area in the short time of two years called for simple but fundamental methods of field study. With the aid of agricultural officials of other countries, we hunted out fields that had been cultivated for a thousand years, or the basis of a permanent agriculture. Likewise, we sought to find the reasons why lands formerly cultivated had been wasted or destroyed, as a warning to our farmers and our city folks of a possible similar catastrophe in this new land of America. A simplified method of field study enabled us to examine large areas rapidly.

In the Zagros Mountains that separate Persia from Mesopotamia, shepherds with their flocks have lived from time immemorial, when "the memory of man runneth not to the contrary." From time to time they have swept down into the plain to bring devastation and destruction upon farming and city peoples of the plains. Such was the beginning of the Cain and Abel struggle between the shepherd and the farmer, of which we shall have more to say.

At Kish, we looked upon the first capital after the Great Flood that swept over Mesopotamia in pre-historic times and left its record in a thick deposit of brown alluvium. The layer of alluvium marked a break in the sequence of a former and a succeeding culture as recorded in artifacts. Above the alluvium deposits is the site of Kish, the first capital in Mesopotamia after the traditional flood as described in the Bible.

At the ruins of mighty Babylon we pondered the ruins of Nebuchadnezzar's stables adorned by animal figures in bas-relief; we stood subdued as at a funeral as we recalled how this great ruler of Babylon had boasted:

"That which no king before had done, I did ... A wall like a mountain that cannot be moved, I builded ... great canals I dug and lined them with burnt brick laid in bitumen and brought abundant waters to all the people ... I paved the streets of Babylon with stone from the mountains ... magnificent palaces and temples I have built ... Huge cedars from Mount Lebanon I cut down ... with radiant gold I overlaid them and with jewels I adorned them."

Then came to mind the warnings of the Hebrew prophets that were thundered against the wicked city, for they warned that Babylon would become "A desolation, a dry land, and a wilderness, a land wherein no man dwelleth ... And wolves shall cry in their castles, and jackals in the pleasant places." Believe it or not, the only living thing that we saw in this desolation that once was Babylon, was a lean gray wolf, shaking his head as if he might have had a tick in his ear, as he loped to his lair in the ruins of one of the seven wonders of the ancient world -- the Hanging Gardens of Babylon where air conditioning was in use 2600 years ago.

Mesopotamia, the traditional site of the Garden of Eden, out of which come the stories of the Flood, of Noah and the Ark, of the "Tower of Babel" and the confusion of tongues, of the fiery furnace which we found still burning today, is jotted full of records of a glorious past, of dense populations and of great cities that are now ruins and desolation. For at least eleven empires have risen and fallen in this tragic land in 7000 years. It is a story of a precarious agriculture by people who lived and grew up under the threat of raids and invasions from the denizens of grasslands and the desert, and of the failure of their irrigation canals because of silt -- silt!

In recent years a great pool of oil was discovered beneath the traditional Garden of Eden. It was escaping gas from this pool that caught fire and became known as the fiery furnace into which, presumably, the three friends of Daniel, Shadrach, Meshach and Abednego, were thrown by an angry King. Income from this rich find of petroleum may well be used to restore this ancient land to more than its former productivity by installations of modern civilization. Scarceley a beginning in this possible reclamation has been made.



Fig. 1. The remains of the prehistoric city of Kish lay buried under the sands of Mesopotamia for thousands of years. During recent years, archaeologists have excavated the ruins shown above. These ruins now lie in a desert - a man-made desert.



Fig. 2. This picture shows part of the excavated ruins of ancient Babylon; which was the capital of most of the civilized world only 4,000 years ago. When Babylon died, it remained dead and was buried under the sands of Mesopotamia; not because it was sacked and razed; but because the irrigation ditches which watered the lands that supported the city were permitted to fill with silt.

In Mesopotamia, agriculture was practiced in a very dry climate on canal irrigation with muddy water. Waters of the Twin Rivers are now heavily charged with the products of erosion out of far mountain gorges and overgrazed hill lands, of the Tigris and Euphrates drainage. This muddy water was the undoing of empire after empire by reason of silt. As muddy river waters slowed down, they choked up the canals with silt. It was necessary to keep this silt out of the canals year after year to supply life-giving waters to farm lands and to cities of the plain. As populations grew, canals were dug further and further from the rivers, until a great system of canals called for a great force of hand labor to keep them clean of silt. This was a very serious problem, for the rulers of Babylon brought in war captives for this task. Now we understand why the captive "Israelites" "sat down by the waters of Babylon and wept," for they also were doubtless required to dig silt out of canals of Mesopotamia.

As these great public works of cleaning silt out of canals were interrupted from time to time by internal revolutions and by foreign invaders, the peoples of Mesopotamia were brought face to face with disaster in canals choked with silt. Stoppage of canals by silt depopulated villages and cities more effectively than the slaughter of people by an invading army.

On the basis of an estimate that it was possible in times past to irrigate 21,000 square miles of the 35,000 square miles of the alluvium of Mesopotamia, the population of Mesopotamia at its zenith was probably between 17 and 25 million. The present population of all Iraq is estimated to be about 4,000,000 including nomadic peoples. Of this total not more than 3,500,000 live on the alluvial plain.

Decline in population, in Mesopotamia is not due to loss of soil by erosion; for the fertile lands are still in place and life-giving waters still flow in the Tigris and Euphrates Rivers, ready to be spread upon the lands today as in times past. Mesopotamia is capable of supporting as great a population as it ever did and greater when modern engineering makes use of reinforced concrete construction for irrigation works and powered machinery to keep canal systems open. A greater area of Mesopotamia thus might be farmed than ever before in the long history of this tragic land. But erosion in the hinterlands aggravated the silt problem in waters of the Twin Rivers, as they were drawn off into the ancient canal systems, and invasions of nomads out of the grasslands and the desert brought about the breakdown of irrigation that spelled disaster after disaster.

We shall leave Mesopotamia now where at least 11 empires rose and fell in the past 7000 years and where the 12th nation of Iraq is now just beginning a new life. We shall travel westward across the Syrian desert, along the probable route of the patriarch Abraham with his family, as he journeyed from Ur of the Chaldeas to the Promised Land of Canaan. We had selected for our survey of Mesopotamia, a period that would fall after the usual spring rains and before the sandstorms of late spring. But we were overtaken by a belated rain and became stuck in the mud. We owe our rescue to the kindness and efficiency of employees of the Iraq

Petroleum Pipe Line Company which was engaged in pumping oil out of the great pool under the Garden of Eden to the Mediterranean Coast, in two pipe lines each more than 600 miles long.

### In Egypt's Land

Let's now turn to the other great center of population growth and development of civilization in the Valley of the Nile, where the mysterious Sphinx ponders problems of the ages as he looks out over the narrow green valley of the Nile lying across a brown and sun-scorched desert.

In Egypt as well as in Mesopotamia tillers of soil early learned to sow food plants of wheat and barley and to grow surplus food that released their fellows for divisions of labor that gave rise to the remarkable civilization that arose in the Valley of the Nile. Our debt to the ancient Egyptians is great.

Here farming grew up with flood irrigation of muddy water where problems of farming were quite different from those of Mesopotamia. Annual flooding with silt-laden waters spread thin layers of silt over the land, raising it higher and higher. In these flat lands of slowly accumulating soil, farmers never met with problems of soil erosion. To be sure, there have been problems, especially since year-long irrigation has been made possible by the Assuan Dam, of salt accumulation and of rising water tables for which drainage is the solution. But the body of the soil has remained suitable for cropping for 6000 years and more.

It was perhaps in the Nile Valley that a genius of a farmer about 6000 years ago hitched an ox to a hoe and invented the plow, thus originating power-farming to disturb the social structure of those times much as the tractor disturbed the social structure of our country in recent years. By this means farmers became more efficient in growing food; a single farmer released several of his fellows from the vital task of growing food for other tasks. Very likely the Pharaohs had difficulty in keeping this surplus population sufficiently occupied; for we suspect that the Pyramids were the first great W.P.A. projects.

### On the Trail of the Israelites

We shall follow the route of Moses out of the fertile irrigated lands of Egypt into a mountainous land where forests and fields were watered with the rain of heaven. Fields cleared on mountain slopes presented a new problem in farming -- the problem of soil erosion, which as we shall see, became the greatest hazard to permanent agriculture and an insidious enemy of civilization.

We crossed the modern Suez Canal with its weird color of blue, now a very important "big ditch," into Sinai where the Israelites with their herds wandered for 40 years. They or some one must have overgrazed the Peninsula of Sinai, for it is now a picture of desolation. We saw in this landscape how the original brown soil mantle was eroded into enormous gullies as shown

by great yellowish gashes cut into the brown soil covering. I had not expected to find evidences of so much accelerated erosion in the arid land of Sinai.

On the way to Aqaba we crossed a remarkable landscape, a plateau that had been eroded through the ages almost to a plain, called a peneplain in physiographic language. This broad flat surface glistened in the sunlight with the colors of the rainbow because of desert varnish on the small stones that had been fitted together through the ages to form a classic example of desert pavement. This peneplain surface dates back to Miocene times, in the geological scale. In the plain now is no evidence of accelerated cutting by torrential streams, no evidence that climate has changed for drier or wetter conditions since Miocene times. Here is a cumulative record going far back of the Ice Age, proclaiming that in this region climate has been remarkably stable.

From this plateau we dropped down 2500 feet into the Araba or gorge of the great rift valley that includes the Gulf of Aqaba, the Araba, the Dead Sea, and the Valley of the Jordan. At the head of the Gulf of Aqaba of the Red Sea we found Dr. Nelson Glueck excavating Ezion Geber which he calls the ancient Pittsburg of the Red Sea, or Solomon's Seaport, where copper was smelted 2800 years ago to furnish instruments for Solomon and his people. The mud brick used for building these ancient houses looked just like our adobe brick of New Mexico and Arizona.

As we climbed out of the rift valley over the east wall to the plateau of Trans-Jordan that slopes toward the Arabian Desert, we came near Amman upon the same type of peneplain that we crossed west of the Araba. This peneplain was covered by a coarser pavement in which were fragments of basalt, but topographically these two plains are parts of the same peneplain that once spread unbroken across this region. But toward the end of Pliocene times -- that is, just before the beginning of the Ice Age -- a series of parallel faults let down into it the great rift valley to form one of the most spectacular examples of disturbances in the earth's crust that is known to geologists.

From Ma'an we proceeded past an old Roman dam, silted up and later washed out and left isolated as a meaningless wall, and on to Elji where we took horses to visit the fantastic ruins of ancient Petra (called Sela in the Old Testament). This much-discussed city was the capital of the Nabatean civilization and flourished at the same time as the Golden Age of China -- 200 B.C. to 200 A.D. Rose-red ruins of a great city are hidden away in a desert gorge on the margin of the Arabian desert.

Petra is now the desolate ruin of a great center of power and culture and has been used by some students as evidence that climate has become drier in the past 2000 years, making it impossible for this land to support as great a population as it did in the past. In contradiction to this conclusion, we found slopes of surrounding valley covered with terrace walls that had fallen into ruin and allowed the soils to be washed off to bare rock over large areas. These evidences showed

that formerly food was grown locally and that soil erosion had damaged the land beyond use for crops. Invasion of nomads out of the desert had probably resulted in a breakdown in these measures for the conservation of soil and water, and erosion had washed away the soils from the slopes and undermined the carrying capacity of this land for a human population. Before ascribing decadence of the region to change of climate, we must know how much the breakdown of intensive agriculture contributed to the fall and disappearance of this Nabatean civilization.

The great buildings used for public purposes are amazing; temples, administrative buildings, and tombs are all carved out of the red Nubian sandstone cliffs. A fascinating story still lies hidden in the unexcavated ruins of this ancient capital. The influence of Greek and Roman civilization was found in a great theater with a capacity to seat some 2500 persons, carved entirely out of massive sandstone rock, which only echoes the scream of eagles, or the chatter of tourists.

And as we proceeded northward in the Biblical land of Moab, we came to the site of Mt. Nebo and were reminded of how Moses, after having led the Israelites through 40 years of wandering in the wilderness, stood on this mountain and looked across the Jordan Valley to the Promised Land. He described it to his followers in words like these:

"For the Lord thy God bringeth thee into a good land, a land of brooks of water, of fountains and depths that spring out of valleys and hills; a land of wheat and barley and vines and fig trees and pomegranates, a land of olive oil and honey; a land wherein thou shalt eat bread without scarceness; thou shalt not lack anything in it; a land whose stones are iron and out of whose hills thou mayest dig brass."

#### The Land of Milk and Honey

We crossed the Jordan Valley as did Joshua and found the Jordan River a muddy and disappointing stream. We stopped at the ruins of Jericho and dug out kernels of charred grain which the archaeologists tell us undoubtedly belonged to an ancient household of this ill-fated city. We looked at the Promised Land as it is today, 3000 years after Moses described it to the Israelites as a "land flowing with milk and honey."

The British Mandate Government for Palestine was very accommodating and furnished an armored car to protect us in our travels against attacks of terrorists, who were very active at that time. The Government also furnished us an airplane with special permission to take pictures from the air. The Jewish Agency gave us all facilities to study the agricultural colonies. Because of this excellent cooperation, we had an excellent view of Palestine as it is today.

We found that the soils of red earth had been washed off the slopes to bed rock over more than half the upland area -- washed off the slopes and lodged in the valleys where they are still being cultivated and still being eroded by great gullies that cut through the alluvium with every heavy rain. Evidence of rocks washed off the hills were found in piles



Fig. 3. This is a present day view of the "Promised Land" to which Moses led the children of Israel. A few patches, like those shown in the foreground, still have enough soil to raise a meager crop of grain. But, as observed from the rock outcroppings, most of the land on the sloping hill-sides has lost practically all soil through man-induced erosion. The crude rock terrace, shown in the middle foreground, helps to hold some of the remaining soil in place.



Fig. 4. This picture, taken near Jerusalem, Palestine, shows a contrast in slopes. The slopes in the foreground and the left middle distance are almost completely bare of soil; while the slopes to the right where crude terraces are seen still retain enough soil to produce a thin crop of grain.

of stone where tillers of soil had heaped them together to make cultivation about them the easier. From the air we read with startling vividness the graphic story as written in the land, where soils have been washed off to bed rock in the vicinity of Hebron and only dregs of the land are left behind in narrow valley floors, there still cultivated to meager crops.

In the denuded highlands of Judea are ruins of abandoned village sites. Capt. P.L.O. Guy, Director of the British School of Archaeology, has studied in detail those in the drainage of Wadi Musrara. These sites were occupied 1500 years ago; since that time they have been depopulated and abandoned in greater numbers on the upper slopes. Capt. Guy divided the drainage of Musrara into three altitudinal zones: The plain, 0-325 feet; foothills, 325-975 feet; and mountains, 975 feet and over. In the plain 34 sites were occupied and 4 abandoned; in the foothills, 31 occupied and 65 abandoned; and in the mountains, 37 occupied and 124 abandoned. Villages have thus been abandoned in the 3 zones by percentages in the above order of 11, 67 and 77, which agrees well with the removal of soil. It is little wonder that villages were abandoned in a landscape such as this in the upper zone near Jerusalem, where the soil, source of food supply, has been wasted away by erosion and only remnants of the land left in drainage channels, held there by cross walls of stone.

Where soils are held in place by stone terrace walls that have been maintained down to the present, we found the soils still cultivated after several thousand years and still producing — not heavily, to be sure, because of poor soil management. Most important, the soils are still in place and will grow bigger crops with improved soil treatment. We also looked upon the glaring hills of Judea not far from Jerusalem, dotted with only a few of its former villages, whose terraces have been kept in repair for more than 2000 years.

What is the cause of the decadence of this country that was once flowing with milk and honey? As we ponder the tragic history of the Holy Lands, we are reminded of the struggle of Cain and Abel, how it has been made realistic through the ages by the conflict that persists even unto today, between the tent dweller and the house dweller, between the shepherd and the farmer. The desert seems to have produced more people than it could feed; from time to time the desert people swept down into the fertile alluvial valleys where, by irrigation, tillers of soil grew abundant foods to support teeming villages and thriving cities. They swept down as a wolf on the fold to raid the farmers and their supplies of food. Raiders sacked and robbed and passed on, often leaving destruction and carnage in their path, or they replaced former populations and themselves became farmers only to be swept out by a later wave of hungry denizens of the desert.

Conflicts between the grazing culture and farming culture of the Holy Lands has been primarily responsible for the tragic history of this region. Not until these two cultures supplement each other in cooperation

can we hope for peace in this ancient land. We saw the tents of descendants of nomads out of Arabia who in the 7th century swept in out of the desert to conquer and over-run the farming lands of Palestine and again in the 12th century when they drove out the Crusaders. They and their herds of long-eared goats, often called cloven-hoofed locusts, let terrace walls fall in ruin and unleashed the forces of erosion which for nearly 13 centuries have been washing the soils off the slopes into the valleys to make marshes or out to sea.

In recent times a great movement has been under way for the redemption of the Promised Land by Jewish settlers, who have wrought wonders in draining swamps, ridding them of malaria and planting them to thriving orchards and fields, in repairing terraces, in reforesting the desolate and rocky slopes, and in the improvement of livestock and poultry. The work of the Jewish colonies is the most remarkable reclamation of old lands that I have seen in three continents.

Throughout our survey of the work of the agricultural colonies, I was asked to advise on measures to conserve soil and water. I urged that trees of orchards be planted on the contour and the land bench-terraced by contour plowing. So insistent was I on this point that finally we were told of one orchard that was planted in this manner. We went to see it. The trees were planted on the contour, the land was bench-terraced and slopes above the orchard were furrowed on the contour and planted to hardy trees. By these measures all the rain that fell the season before, one of the wettest in many years, was absorbed by the soil. No runoff occurred after this work was done, to cut gullies down slope and to damage the orchards below. When I asked where the man responsible for this had learned these measures, he told me that he had learned them at the Institute of Water Economy in Tiflis, Georgia, in Trans-Caucasia.

#### Across Syria

We crossed the Jordan again into a region famous in Biblical times for its oaks, wheat fields and well-nourished herds, where we found the ruins of Jorash, one of the ten cities of the Decapolis, and Jerash the second. Archaeologists tell us that Jerash was once the center of some 250,000 people. But today only a village of 3000 marks this great center of culture, and the country about is sparsely populated with semi-nomads. The ruins of this once powerful city of Greek and Roman culture are buried to a depth of 13 feet with erosional debris washed from eroding slopes. Excavation by archaeologists has disclosed the beauty and grandeur of the main street of Jerash that was lined with stately columns with beautifully carved capitals for which the city was famous throughout the Near East.

We searched out the sources of water that nourished Jerash and found a series of springs protected by masonry built in the Graeco-Roman times. We examined these carefully with the archaeologists to discover whether the present water level had changed with respect to the original structures and whether the openings through which the springs gushed was the same as that of ancient times. We found no suggestion that the water level was any lower than it was when the structures were built or that the openings were different. It seems that the water supply had not failed, but when we examined the slopes surrounding Jerash we found the soils washed off

to bed rock in spite of rock walled terraces. The soils had been washed off the slopes and lodged in the valleys, there to be cultivated by the semi-nomads who lived in black goat-hair tents, whereas in Roman times this area supplied grain to Rome and supported thriving communities and rich villas, ruins of which we found in the vicinity.

Further to the north near Hama, we came to an area of gently sloping lands in Syria where wheat is still grown after thousands of years of cultivation. Mr. Hibrani, an Arab gentleman farmer who seeks to put modern farm machinery to use on his large holdings with poor success, told me this story: Some time ago an Arab land owner sent his son to a modern university to learn the law. After graduation the son did not find the law to his liking and returned to his father who made him overseer of the threshing floor. The son was watching the two piles of threshed grain grow equally, one for the landlord, the other for the tenant. Then he asked the tenant, "What becomes of the straw?" The tenant replied, "The tenant gets all the straw." The lawyer son then commanded the tenant, "Next year you are to plant only wheat, but plant no straw." Tillers of soil have been exploited since slavery was invented in Egypt, and they in turn have exploited the earth.

In the alluvial plains along the Orentes River agriculture supports a number of cities, but much reduced in population from those of ancient times. Water wheels introduced from Persia during or following the conquests of Alexander the Great (300 B.C.) were numerous along the Orentes -- hundreds, we were told, in Roman times, but today only 44 remain. They are picturesque old structures both in their appearance and in the groans of the turning wheel as they slowly lift water from the river to the aqueduct to water the city of Hama. These wheels are more than 2000 years old, but no part of the wheel is that old, because the parts have been replaced piecemeal many times through the centuries.

#### The Hundred Dead Cities

Still further to the north in Syria, we came upon a region where erosion had done its worst in an area of more than a million acres of rolling limestone country between Hama, Aleppo, and Antioch. French archaeologists, Father Mattern and others, found in this man-made desert more than 100 dead cities, and called it "cent villes mortes," or a "Hundred Dead Cities." Butler of Princeton rediscovered this region a generation ago and aroused interest in the area. These were not cities as we know them, but villages and market towns. Here by field examination at Bare and Hirbet Haas we found that soils had been washed off to limestone bed rock to a depth of from 3 to 6 feet. The ruins of these towns were not buried as other ruins such as we saw elsewhere, but were left as stark skeletons in beautifully cut stone, standing high on bare rock. Measurements from doorsills to the foundation rock indicated that soils to a depth of 3 to 6 feet had been washed off and swept away in winter floods, leaving a region of ghost cities. Here erosion had done its worst. If the soils had remained, even though the cities were destroyed and the populations dispersed, the area might be repeopled again and cities rebuilt. But now that soils are gone, all is gone.

We are told that in 610-612 A.D. a Persian army invaded this thriving region and less than a generation later, in 633-638, the nomads out of the Arabian desert completed the destruction of the villages and dispersal of the population so that all the measures for conserving soil and water that had been built up through centuries were allowed to fall into disuse and ruin; then erosion was unleashed to do its deadly work in making this area a man-made desert.

From the air we got a vivid idea of what had happened to the villages of this area where a civilization of an unusually high type had grown up and developed a distinctive architecture. It was a Christian civilization with great churches, ruins of which are still seen in Baalbek. We saw Christian symbols carved into stone doorposts indicating that the house-holders were not ashamed to confess their faith, and we saw the ruins of many Christian churches.

#### Looking for the Forests of Lebanon

About 5000 years ago, we are told by archaeologists, a Semitic tribe swept in out of the desert and occupied the eastern shore of the Mediterranean and established the harbor towns of Tyre and Sidon. On the site of another such harbor town is Beirut, which today is the capital of the republic of Lebanon. You can see it from a high point on the Lebanon Mountains overlooking the Mediterranean Sea.

These early Semites were Phoenicians, who found their land a mountainous country with a very narrow coastal plain and little flat land on which to carry out the traditional irrigated agriculture as it had grown up in Mesopotamia and Egypt. We may believe that as the Phoenician people increased, they were confronted with three choices: (1) of migration and colonization, which we know they did; (2) of manufacturing and commerce, which we know they did; and (3) of cultivation of slopes, about which we have hitherto heard very little.

Here was a land covered with forests and watered by the rains of heaven, a land that held entirely new problems for tillers of soil who were accustomed to the flat alluvial valleys of Mesopotamia and the Nile. As forests were cleared either for use or for commerce, slopes were cultivated. Soils of the slopes eroded then under heavy winter rains as they would now. Here under rain-farming, tillers of soil for the first time encountered severe soil erosion and the problem of establishing a permanent agriculture on sloping lands.

We find as we read the record written on the land in this fascinating region, tragedy after tragedy deeply engraved on the sloping land where efforts to hold back the life-giving soil were developed to high stages of refinement and were later allowed to fall into ruin. We saw many slopes that were once covered with forests where the trees had been cut and the land cleared and cultivated. Soil began forthwith to erode under seasonal winter rains; efforts were made to control erosion by constructing walls across the slopes, of which we see ruins here and there today. For one



Fig. 5. This hillside in Trans-Jordan was once covered with a layer of productive soil. Sheet erosion probably removed most of the topsoil during the first century of use. Gullies then began to form. As the gullies grew thicker and deeper, practically all topsoil and subsoil were removed from the entire slope. Man has put this land back almost to the stage it was in when nature first started to build soil on it.



Fig. 6. Ancient rock-walled bench terraces protect this Lebanon hillside after thousands of years of use. It is estimated that the terracing of some Lebanon hillsides cost at least \$2,000 per acre, if we should figure the cost of labor at 40 cents per hour. Such expensive methods of protecting the land are practical only where people have no other land on which to produce their food.

reason or another, these measures failed, and the soil mantle shifted down slope under the action of progressive erosion. As the fine-textured soil was washed away leaving loose rocks at the surface, tillers of the soil piled them together to make cultivation about them the easier. In these cases the battle with soil erosion was definitely a losing one.

Elsewhere we found how the battle with soil erosion had been won by the construction and maintenance of a remarkable series of rock-walled terraces from the bases to the crests of slopes, like fantastic stair-cases. At Beit Eddine in the mountains of Lebanon east of Beirut, we found the slopes terraced even up to grades of 76 per cent. At wages of 40 cents per hour it would cost \$2000 to \$5000 an acre to build such structures on 50 to 75 per cent slopes. These vast works, an arresting monument to the labor of tillers of soil throughout thousands of years, show the length to which a people will go to save their soils when necessity for food requires it.

Some say we cannot afford to build terraces at such fabulous costs; but these people did so, and we would do as much if it were necessary to survive. We spent more than 300 billion dollars to defend our land against foreign foes during World War II; we would do as much to save our land from erosion if it were necessary. Our war effort averaged more than \$150 for every acre of land in continental United States and more than \$700 for every acre of cultivated land. Who says we cannot afford it? But, fortunately, by the science of conservation we can save our soils for sustained use at a mere fraction of the cost of defending our land from invasion by the Army or planes of an enemy country.

The mountains of ancient Phoenicia were once covered by the famous forests of cedars of Lebanon. An inscription on the temple of Karnak as translated by Breasted, announces the arrival in Egypt before 2900 B.C. of 40 ships laden with timber of cedar out of Lebanon. You also recall that it was King Solomon, nearly 3000 years ago, who made an agreement with Hiram, King of Tyre, to furnish him cypress and cedars out of these forests for the construction of the temple at Jerusalem. Solomon supplied 80,000 lumberjacks to work in the forest and 70,000 to skid the logs to the sea. It must have been a heavy forest for such a woods force. What has become of this famous forest that once covered nearly 2000 square miles?

This forest was protected in Roman times to grow timber for the Roman fleet as told by inscribed monuments. In the mountains of Lebanon, many monuments were found marked with the letters, "H.D.S." Their meaning was not understood until a stone was found and carried to the museum of the American University at Beirut. The inscription is interpreted to read: "Emperor Hadrian Augustus, Forest Boundary" (Emp. Hdn. Aug. Definitio Silvarum), indicating that in the time of Emperor Hadrian the boundaries of these forests were marked for protection.

But today only 4 small groves of this famous Lebanon cedar forest are left, the most important of which is the Tripoli grove of trees in the cup of a valley. An examination of the grove revealed some 400 trees of which 43 are old veterans or wolf trees. As we read the story

written in tree rings, it appears that about 300 years ago the grove had nearly disappeared with no less than 43 scattered veterans standing. These trees with wide-spreading branches had grown up in an open stand. About that time a little church was built in their midst that made the grove sacred; a stone wall was built about the grove to keep out the goats that grazed over the mountains. Seeds from the veterans fell to the ground, germinated and grew up into a fine close-growing stand of tall straight trees that show how the cedars of Lebanon will make good construction timber when grown in forest conditions.

Such natural restocking also shows that this famous forest has not disappeared because of adverse change of climate, but that under the present climate it would extend itself if it were safeguarded against the rapacious goats that graze down every accessible living plant upon these mountains.

As we read in the Hold Lands records of decline and ruin and oblivion of great empires of the past, we were moved by the ineffable sadness and tragedy of man's failures to find a lasting adjustment to his land resources. Time after time as I pondered tragic ruins of great centers of power and culture and the even more tragic ruins of the lands that supported these teeming centers of population, the question would come to mind: Must our fair country of America rise to great power and strength only to decline and fall, because we fail to find a solution to this age-old problem of a permanent source of abundant and adequate food? Have we the intelligence -- have we the will to establish here a lasting nation where the dream of liberty for all is planted? Here is a challenge to the perennial youth of our land!

#### China's Sorrow

Before proceeding to Cyprus and North Africa, let's take a look at China, whose civilization probably arose somewhat later than that which developed in the Near East and was partly influenced by it. Mixed agriculture, irrigation, the ox-drawn plow, and terracing of slopes are notable similarities in the two regions.

It was in China, while I was engaged in an international project for famine prevention in 1922-27, that the full and fateful significance of soil erosion was first burned into my consciousness.

During an agricultural exploration into regions of North China seriously affected by the famine of 1920-21, I examined the site where the Yellow River in 1852 broke from its enormous system of inner and outer dykes. As we traveled across the flat plains of Henan we saw a great flat-topped hill looming up before us. We traveled on over the elevated plain for seven miles to another great dyke that stretched across the landscape from horizon to horizon. We mounted this dyke and, behold! there lay before us the Yellow River, the Hwang Ho, a great width of brown water flowing quietly that spring morning into a tawny haze in the east.

A brisk chilly wind tugged at our clothing, as we contemplated this scene of tremondous implications. Here lay the river known as China's

Sorrow for thousands of years, apparently harmless, in a channel fully 40 to 50 feet above the plain of the great delta. This gigantic river had been lifted up off the plain over its entire 400-mile course across its delta and had been held in this channel by the hand labor of men, without machines or engines, without steel cables or construction timber and without stone. The longer I pondered this awe-inspiring scene, the more was I amazed at the magnitude of the accomplishment of millions of Chinese farmers literally with their bare hands and carrying-baskets, who through thousands of years had built here a stupendous monument to human cooperation and the will to survive. I became oblivious of the chill of the wind that kept tugging at my clothes, lost in wonder and admiration of the nameless and unsung heroes who had fought the battle of floods with this tremendous dragon of a river since the days of Ta-Yu, nearly 4000 years ago, and had lost and won time and again.

But why should this battle with the river have to be endless? Any relaxation of vigilance let the river break over its dykes, calling for herculean and cooperative work of hundreds of thousands of farmers to put the river back again in its channel. Then suddenly it dawned upon me that the river water was brown with silt, heavily laden with soil that was washed out of the highlands of the vast drainage system of the Yellow River. As the flood waters of China's Sorrow reached the gentler slope of the delta (one foot to the mile) the current slowed down and began to drop its load of silt. Deposits of silt in turn lessened the capacity of the channel to carry flood waters and called on the farmers threatened with angry floods to build up the inner and outer dykes yet higher and higher, year after year.

There was no end to this demand of the river if it were to be confined between its dykes. Final control of the river so heavily laden with silt was hopeless; yet hopeful millions of farmers toiled on.

In 1852, the yellow-brown waters of the Hwang Ho broke out of its elevated channel to seek another way to the sea. It had emptied into the Yellow Sea, where it usurped the old outlet of the Shai River. This time the river broke over its dykes near Kaifeng, Honan, and wandered to the northeast over farm lands, destroying villages, smothering the life out of millions of humans and discharged into the Gulf of Chihli, 400 miles north of its former outlet. China's Sorrow in its rage had refused to be lifted any higher off its plain. Hundreds of thousands of farmers had been defeated. Silt -- its unending accumulation in the channel of the Yellow River -- had defeated them, valiant as they were.

Silt - silt - silt! As we were aroused by the tugging of the cold wind, we turned away determined to learn where this silt came from, even up to the head waters.

In a series of carefully planned agricultural explorations we discovered the source of the silt that brought ruin to millions of farmers in the plains. In the Province of Shansi we found how the line of cultivation was pushed up slopes, following the clearing away of forests. Soils formerly protected by a forest mantle were thus exposed to the dash of summer rains, and soil erosion began a headlong process of land destruction

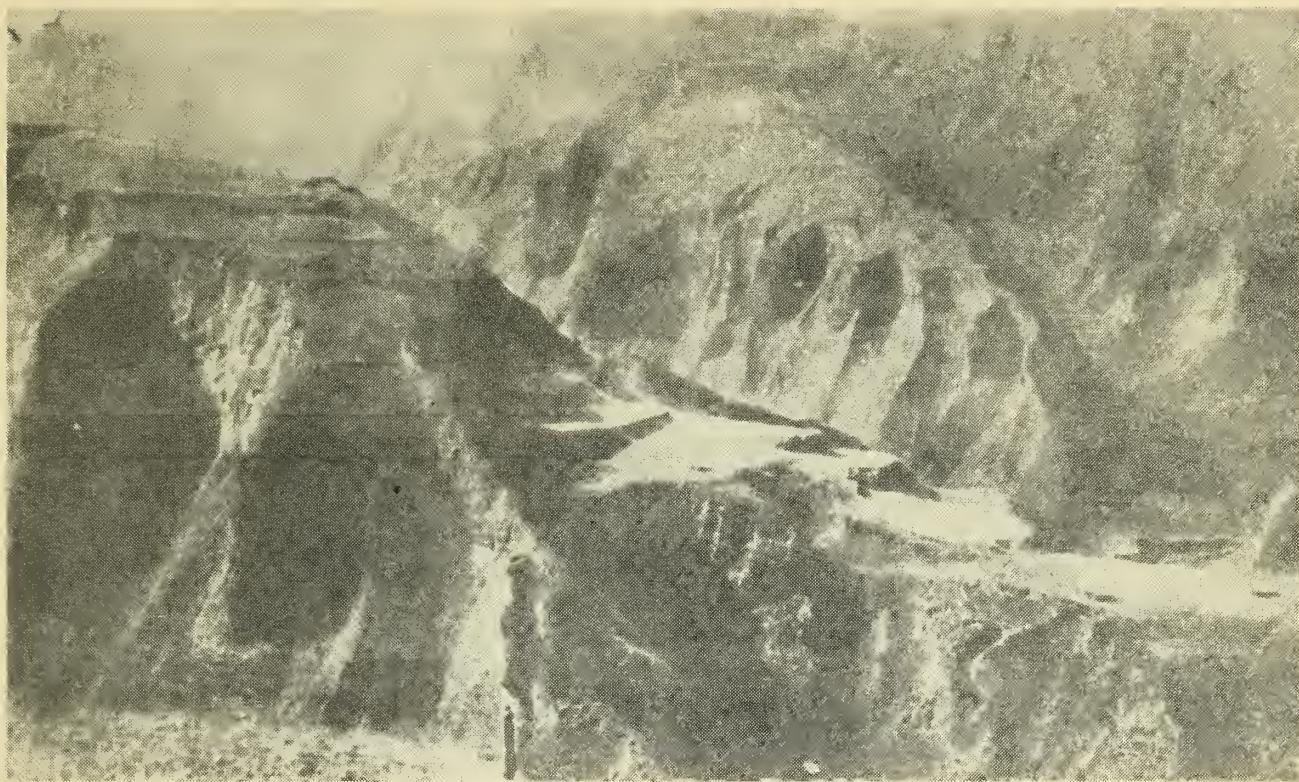


Fig. 7. A severely gullied area in the loess hills of North China. These hills were once covered with trees and grass; but cultivation started the ruinous process of erosion. There are thousands of acres like this in China today. It produces nothing except yellow mud to clog the Yellow River with silt.



Fig. 8. These bench terraces in Shan-Si province, China, again illustrate the extent to which people will go to save their soil when they do not have enough good land to produce their food.

and filling of streams with soil waste and detritus.

Without a basis of comparison, we might easily have misread the record as written there on the land. But temple forests, preserved and protected by the Buddhist priests, gave me and my Chinese associates a remarkable chance to measure and compare the rates of erosion within these forests and on similar slopes and soils that had been cleared and cultivated. The story of these fascinating studies is too long to include in this paper; it is reported in the Proceedings of the Pan-Pacific Science Congress, Tokio, 1926.

In brief, my Chinese scientific associates\* and myself carried out a series of soil erosion experiments during rainy seasons of 3 years in which we measured the rate of runoff and erosion by means of runoff plots within temple forests and out on farm fields under cultivation or abandoned because of erosion. It was on such slopes as these that we got for the first time in soil erosion studies, experimental data on such comparisons. Here too, we found how the Yellow River had become China's Sorrow, for we found that runoff and erosion from cultivated land were many times as great as from temple forests, whereas they caused heavy losses of soil from cultivated land.

It was clear that if the farmers of the delta plain were ever to be safeguarded from the mounting perils of the silt-laden Yellow River, the source of the silt must be stopped by measures of erosion control.

Further west in the midst of the famous and vast loessial deposits of North China, we found in another exploration in the Province of Shensi, how an irrigation system that was first established in 246 B.C. had been put out of use by silt. Here again silt was the villain in the tragedy of the land. Silt was undoing the anxious and unending labor of the Chinese to establish a lasting adjustment to their land. We sought out the origin of the silt that had brought an end to an irrigation project which had fed the sons of Han during the Golden Age of China. The origin was found in areas where soil erosion had eaten out of the land gargantuan gullies 600 feet deep, that were advancing headward into the great mantle of fertile loessial soil. One may see remnants of terraces that were in use before the landscape was riddled by huge gullies. It was while contemplating such scenes that I resolved to challenge the conclusions of the great German geologist, Baron von Richthofen, and of Ellsworth Huntington, that the decadence of North China was due to desiccation or pulsations of the climate.

Temple forests gave the clue; they demonstrated beyond a doubt that the present climate would support a generous growth of vegetation capable of preventing erosion on such a scale. Human occupation th the land had set in motion processes of soil wastage that were in themselves sufficient to account for the decadence and decline of this part of China, without adverse change of climate. In other words, soil erosion unless controlled, will undermine a civilization. I could see that it had already done so, and, unless ways to control it were found, it would bring desolation to others including my own country.

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\* T. I. Li, C. T. Ren, C. O. Lee and others.

It was in the presence of such tragic scenes on a gigantic scale that I resolved to run down the nature of soil erosion, which had proved to be the insidious enemy of civilization and to devote my lifetime to study of ways to conserve the lands on which mankind depends. Out of this experience grew a series of scientific studies in China during the years 1923-27, as reported elsewhere, which were transferred to the United States in 1927 and have been incorporated in erosion and stream-flow investigations of the U. S. Forest Service and later in our movement for land conservation in the United States, under the leadership of Dr. H. H. Bennett, Chief of the Soil Conservation Service.

#### Soil Waste in Ancient Cyprus

Let's now go back and follow the westward course of civilization from the Holy Lands through North Africa and on into Europe. We shall first stop in Cyprus where we found the land-use problems of the Mediterranean epitomized in a comparatively small area. If one wishes to study land use in the Mediterranean region he will find in Cyprus a summary of all major problems brought together within a small area -- an introduction to, or a summary of, problems of land use of the lands surrounding the Mediterranean Sea.

In the plain of Mesaoria is written a telling record in and about a Byzantine church. The church on the outskirts of the village of Asha in eastern Cyprus is surrounded by a graveyard and its wall. The alluvial plain now stands 8 feet above the level of the churchyard as we measured it. On entering the church we stepped down 3 feet from the yard level to the floor of the church; but inside the church we noted that low pointed arches were blocked off, and new arches cut for doors and windows. The aged vestryman told us that about 30 years ago a flood from the plain had filled the church with water and left 2 feet of silt on the floor. Rather than clean it out, a new stone floor had been laid over the silt deposit. Thus, 8 plus 3 plus 2 equals 13 feet, the height of the present alluvial plain above the church floor. From these measurements we concluded that the plain had filled in not less than 13 feet, very probably more, with erosional debris washed off the drainage slopes. This church proclaims silently and eloquently the progressive wastage of soils of the surrounding hill lands that have been cultivated up steep gradients.

#### Across North Africa

We shall now continue westward along the northern coast of Africa into Tunisia, and Algeria. Here we read the record of the granary of Rome in North Africa during the Empire, by surveying a cross section across North Africa from the Mediterranean to the Sahara Desert, from 40 inches of rainfall to 4 inches, from Carthage on the coast to Biskra at the edge of mysterious Sahara.

In Tunisia we found that it rains in the desert of North Africa in winter time now as it did in the time of Caesar, who in 44 B.C. complained of how a great rainstorm with wind had blown over the tents of his army encampment and flooded the camp. It rains hard enough to produce flash

floods in the wadies. At one place muddy water swept across the highway in such volume that we decided to wait until the next day until the flash flow had gone down before proceeding.

As we make a rapid survey of land use across Tunisia and Algeria from the Mediterranean coast to the edge of the Sahara, through the center of what was the granary of Rome, we shall begin at Carthage the principal city of North Africa in Phoenician times.

We stood on the site of ancient Carthage, one of the colonies of Phoenicia that grew to be great and powerful -- the city that produced Hannibal and became a dangerous rival of Rome. In 146 B.C. at the end of the Third Punic War, Scipio destroyed Carthage, but out of the doomed city he saved 28 volumes of a work on agriculture written by a Carthaginian by the name of Mago, who was recognized by the Greeks and Romans as the foremost authority on agriculture in the Mediterranean. These works of Mago were translations in the existing works of such Roman writers on agricultural subjects as Columella, Varro, and Cato. This incident tells us that the traditions of conserving soils and waters that we believe were first discovered on the slopes of ancient Phoenicia had been brought by their colonists to North Africa; we suspected these measures furnished the basis of the great agricultural production that was so important to the Romans during the Empire.

Over a large portion of the ancient granary of Rome we found the soil washed off to bed rock and the hills seriously gullied from overgrazing. The valley floors are usually still cultivated but are still eroding in great gullies fed by accelerated storm runoff from barren slopes. This was in an area that once supported many great cities in Roman times.

We found at Djemila the ghosts of Cuicul, a city that was once great and populous and rich but later was covered completely, except for about 3 feet of a single column, by erosion debris washed off slopes of surrounding hills. For 20 years French archaeologists had been excavating this remarkable Roman city and unearthed great temples, two great forums, splendid Christian churches, and great warehouses for wheat and olive oil. All this had been buried by erosional debris washed from the eroding slopes above it. The surrounding slopes once covered with olive groves are now cut up with active gullies.

The modern village that falls heir to this once beautiful Roman city houses only a few inhabitants. The flat lands are still farmed to grain but the slopes once planted to olives are bare and eroding and wasting away. What is the reason for this astounding decline and ruin?

#### Timgad, Lost Capital of a Lost Agriculture

Further to the south we stopped to study the ruins of another great Roman city of North Africa, Thamugadi, now called Timgad. This city was founded by Trajan in the first century A.D., laid out in symmetrical pattern and adorned with magnificent buildings, with a forum embellished by statuary and carved porticoes, a public library, a theater to seat some



Fig. 9. (L-132) In the middle distance may be seen the ruins of the ancient Roman city of Cuicul. This was a rich and prosperous city in North Africa when that region was known as the "granary of the Roman Empire". Note that the ruin of the land, as seen in the distance and foreground, is almost as complete as the ruin of the city.



Fig. 10. This small flock of scrawny sheep graze on the scant vegetation that may be found near the ruins of Cuicul. This is about the only productive use the land now has; the gullied hillsides in the distance do not even support enough vegetation for that.



Fig. 11. The ruins of Timgad - another ancient Roman city of North Africa. The few squalid huts, seen in the middle distance, now house about 300 inhabitants; which is all that the eroded land will support at present - another example of a city that remains dead because the land that supported it is dead.



Fig. 12. (L-141) This large grove of olive trees are thriving on the plains near Sfax, Tunisia. The scattered groves of this kind that may be found in North Africa today show that the climate is still suitable for agriculture where productive soil is still on the land.

2500 persons, 17 great Roman baths, and, if you please, with marble flush toilets for the public. After the invasion of the nomads in the seventh century had completed the destruction of the city and dispersal of its population, this great center of Roman culture and power was lost to knowledge for 1200 years. It was buried by the dust of wind erosion from surrounding farm lands until only a portion of Hadrian's arch and 3 columns remained like tombstones above the undulating mounds to indicate that once a great city was there.

Since discovery of the site, the French Government has been excavating this great center for 30 years and has disclosed remarkable examples of building, of art, and of ways of living during Roman times in North Africa, all supported by the agriculture of the "Granary of Rome." The mosaics that lined the public baths were beautiful in design. Within the city we found ruins of a great bakery with its many grist mills turned by slaves to grind the wheat that grew on the plains. But today this great center of power and culture of the Roman empire is desolation; it is represented by a modern village of only a few hundred inhabitants who live in squalid structures, the walls of which are for the most part built of stone quarried from the ruins of the ancient city.

We saw also where water erosion cut a gully down into the land and exposed an ancient aqueduct that supplied water to the city of Timgad from a great spring some 3 miles away. Within and surrounding Timgad, we studied remarkable ruins of great olive presses where today there is not a single olive tree within the circle of the horizon.

On the plain of Tunisia we came upon in El Jem, the ruins of a great coliseum, second only in size to that of Rome, for the amusement of a city in a populous region. It was built to seat some 65,000 people, whereas it would be difficult to find 5000 persons today within this district. The ancient city now lies buried around the coliseum and a sordid modern village is built on the buried city.

What was the cause of the decadence of North Africa and the decline of its population? Some students have suggested that the climate changed and became drier, forcing people to abandon their remarkable cities and works. But Gsell, the renowned geologist who studied this problem for 40 years, challenged the conclusion that the climate has changed in any important way since Roman times. So Director Hodet, of the Archaeological Excavations at Timgad, decided as an experiment to plant olive trees on an unexcavated portion of the city where there would be no possibility of sub-irrigation. He planted young olive trees in the manner prescribed in Roman literature, watering them in the following two long dry summer seasons. These olive trees are thriving, indicating that where soils are still in place, olive trees will grow today probably very much as they did in Roman times.

On the plains about Sfax, ruins of olive presses were found by early travelers, but no olive trees. An experiment was decided upon 40 years ago to plant olive trees there, and they grew. Now more than 150,000 acres are

planted to olive trees, and their products support thriving industries in the modern city of Sfax. These plantings indicate that the climate of today, as far as production of olives is concerned, is not unlike that of Roman times; in other words, that the climate has not become drier in a significant degree since Roman times.

Other students of this baffling problem have suggested that pulsations of climate with intervening dry periods have taken place, sufficient to blot out the civilization of North Africa. Such undoubtedly might have been the case, but at Sousse we found telling evidence on this point in an olive grove that has survived since Roman times. These olive trees are at least 1500 years old, we were informed. I was interested in the way these trees were planted -- in basins bordered by banks of earth with ways of leading in unabsorbed storm runoff from higher ground. We passed along this area at a time of heavy rains which showed just how this method had worked since the trees were first planted. If there have been pulsations of climate since Roman times this grove should show that the drier periods were not sufficiently severe to kill the olive trees. We conclude that it does not seem probable that either a progressive change of climate or pulsations of climate account for the decadence of North Africa. We must seek other causes for this colossal tragedy.

On hillsides between Constantine and Timgad, we found written on the land a record that indicates what has happened to soils of the granary of ancient Rome. We found some hills which, according to the botanists, were covered with savannah vegetation of scattered trees and grass. Vegetation had conserved a layer of soil on these hills for unknown ages. With the coming of a grazing culture brought in by invading nomads of Arabia, erosion was unleashed by overgrazing of the hills. We can see written here on the landscape how the soil mantle was washed off the upper slopes to bed rock. Accelerated runoff from the bared rock cut gullies into the upper edge of the soil mantle, working it down hill as if a great rug were being pulled off the hills, and depositing material at lower levels. The accumulation of torrential flows during winter storms is cutting great gullies through the alluvial plains just as it does in New Mexico, Arizona, and Utah of our own country. The effect of this is to lower the water table, bringing about the effects of desiccation without reduction in rainfall. In this manner has the country been seriously damaged and its capacity to support a population much reduced. Unleashed and uncontrolled soil erosion is sufficient to undermine a civilization, as we found in North China and as seems to be true in North Africa as well.

#### The Dry Lands of North Africa

We traveled across North Africa southward toward the Sahara Desert into zones of less and less rainfall. Beyond the cultivated area in Roman times was a zone devoted to stock raising on a large scale. Thousands of cisterns were built in Roman or pre-Roman times to catch storm runoff from the land to store it for outlying villages and for watering herds of livestock during the dry summer seasons. Many of these cisterns were being cleaned out and repaired by the French Government before World War II, to use for the same purpose as they were used for in ancient times. And the French Government was going the Romans one better because of the advantage in

steel reinforced concrete construction. We looked upon one of the modern cisterns four times as large as any Roman cistern, with a capacity of 100,000 cubic feet. This cistern was filled in two years and now waters the herds of semi-nomads who inhabit this portion of North Africa.

Still farther toward the desert about 70 miles south of Tebessa we found a remarkable example of ancient measures for the conservation of water. At some time in the Roman or possibly pre-Roman period, peoples of this region built check dams to divert storm water around the slope -- in canals that the French are now cleaning out again -- to spread upon a remarkable series of bench terraces. This area of unusual interest raises a number of puzzling questions which we are not yet able to answer. If these terraces were cultivated to crops in times past they are the best evidence we have that climate has become drier since they were first built. But if they were built for spreading water to increase forage production for grazing herds then, as the French are using them today, they are not evidence for an adverse change of climate. This evidence alone could leave us in doubt, but other evidence would indicate that water spreading was most used here for crops.

This region of North Africa is similar to the Navajo country in the United States where in recent years our Soil Conservation Service has developed measures for spreading storm water on alluvial valley floors to increase forage growth for herds of Navajo sheep. It would be interesting to know the date and the reason for building these terraces. They may indicate that with Roman occupation of North Africa the native tribes were driven beyond the border of the Roman Empire and were forced to devise these refined measures for conservation and use of water in a dry area; or they may indicate that North Africa was so densely populated that it was necessary to use these refinements in the conservation of water to support the population on the margins of a crowded region. Whatever may be the answers to these questions, the French Government during our visit in North Africa in 1939, was in the course of restoring these ancient practices of diverting storm water with check dams around slopes in canals to spread it upon the gentle slopes that had been flattened by a remarkable series of bench terraces.

We passed through the Saharan Atlas mountain range by a narrow valley and into the mysterious Sahara Desert that spreads out toward the horizon as a faint blue sea. Salmon-colored sands form restless dunes that wander hither and yon in a lifeless landscape. At the north wall of the Sahara Desert, near the foot of the mountain wall we came upon the oasis of Biskra. We found the oasis a refreshing contrast to the glare of the desert. This oasis is nourished by sweet water from great springs issuing at the foot of limestone mountains.

The importance of an oasis in North Africa is measured not by the number of its inhabitants, but rather by the number of its date-palm trees. The oasis of Biskra has 250,000 date palms that furnish crops of delicious dates, as we know from personal experience, that are the chief articles of trade in the markets and the chief article of diet of the people.

We have now completed a transect across North Africa from 40 inches of rainfall on the coast to 4 inches at Biskra -- across the granary of Rome -- and have seen how great cities were built and grew up in this fertile region supported chiefly by crops of grain and olive oil. We have told how these great cities were abandoned and the former dense population dispersed; how the cities were buried in the overwash of erosional debris from eroding hills and by the dust of wind erosion from surrounding farm lands, and lost to knowledge for a period of 1200 years. We have noted the evidences that this decline and decadence of North Africa was neither due to a progressive adverse change of climate nor to pulsations of climate, but was due to the breakdown of an agriculture of remarkable refinements which arose out of colonization by the Phoenicians who, we believe, brought from ancient Phoenicia the solutions to problems of conserving soils and waters encountered in their mountainous homeland.

Soil erosion by water and by wind has so damaged this once fair province of the Roman Empire that its capacity to support people has been much reduced. The soils have been washed off the hills and deposited in the valleys, where they may still be cultivated but are still eroding, as we saw by great gullies that cut through alluvial valley fills.

While the land has been seriously damaged, as you can see written on landscape after landscape, the country is still capable of far greater than its present production. In Roman times a high stage of conservation of soils and waters was reached with an intensive culture of orchards and vineyards on the slopes and intensive grain-growing in the valleys. All this depended on efficient conservation and use of the rainfall. We find numerous references to such practices in the literature of the time. But as nomads swept in out of the desert, their extensive and exploitative grazing culture replaced these highly refined measures of land use and let them fall into disuse and ruin. Erosion was unleashed on its destructive course, and the capacity of the land to support people was seriously reduced.

The veteran student of North Africa, Prof. Gautier, answered my query as to whether climate of North Africa had changed since Roman times, in the following way: "We have no evidence to indicate that the climate has changed in an important degree since Roman times; but," he said, "the people have changed." We conclude that the decline of North Africa is due to a change in a people and more especially to a change in culture and methods of use of land that replaced a highly developed and intensive agriculture and that allowed erosion to waste away the land and to change the regime of waters.

#### A Word About Land Use in Italy

We shall now cross the Mediterranean sea to Italy. The westward course of civilization has left its marks in Italy. We found at Paestum, south of Naples, one of the best preserved of Greek temples located on the coastal plain near the sea. Here there was no overwash of erosional material or accumulation of dust from wind erosion, and no gully erosion in the plain. We walked on the same level as the Greeks who built the temple 2600 years ago.

But population pressure in Italy under its smiling climate and blue skies has pushed the cultivation line up the slopes to dizzy gradients and caused the building of villages on picturesque ridge points. In Italy there are 326 persons per square mile of cultivated land, while in the United States, there are only 208. This method of comparison of population density gives us the advantage because of our vast grazing lands that support great herds of livestock. But if we had the same density of population per square mile of cultivated land in the United States as has Italy, we should have 520 million people instead of our 130 million. This gives us some idea of the relative densities and pressures of population upon the land and accounts for the intensive use not only of the plains, but of the slopes up to steep gradients in Italy.

We haven't space to tell the details of how the Pontine Marshes, that for 2000 years defied the efforts at reclamation of former rulers of Italy, were successfully reclaimed recently. This former pestilential area has been drained and rid of malaria and is now divided into farms equipped with reinforced concrete houses of attractive design, where families are established free from perils of malaria and safe in the security of their land.

#### Torrent Control in the French Alps

As we proceeded into southeastern France, we found the same condition of intensive use of the land on valley floors and on the slopes, which are terraced up to steep gradients. We saw how, in the French Alps, population pressure on land of the plains has pushed the cultivation line up the slopes into mountains and where grassy meadows were overgrazed.

This excessive use of the mountainous areas in the French Alps unleashed torrential floods that for more than a century ravaged productive alpine valleys. Erosional debris was swept down by recurring torrential floods to bury fields, orchards and villages, to cut lines of communication and to kill inhabitants of the valleys. So serious became this menace to the welfare of the region that the French Government, after much study and legislation, undertook in 1882 a constructive program of torrent control. Since that time, funds of hundreds of millions of francs have been spent for works of torrent control that are remarkably successful. The French forest engineers have worked out many of the problems that confront us in this new land in the control of torrential floods in mountainous areas. By an intensive study of these problems and solutions in France, we may gain much time and save much money in this country in our flood control program.

We found where the debris washed out of the mountains had filled up streams in the valleys, causing water tables to rise to damage crops on bordering alluvial lands which are the most fertile and productive in the mountainous region. The lesson here is to keep the soil on the slopes where it belongs, rather than letting erosion impoverish the mountains and damage the valleys.

### Intensive Land Use in France

We found slopes in southern France cultivated on gradients up to 100 per cent, where terrace walls were as high as the benches were wide. Some of these terraced fields had been under cultivation for more than a thousand years -- and likely much longer, for the Phoenicians are believed to be responsible for terracing in this part of France.

When the soils of these age-old terraces become "fatigued" or tired, as the French say, they are turned over to a depth of more than 3 feet once in 15 to 30 years as the need may be. Thereafter a cover crop is planted on the newly exposed soil material for two or more years, followed by plantings of orchard trees or vines or vegetables.

In eastern France we found adjustments of farming to slopes in various stages. In places, terraces are built with rock walls on the contour to reduce slope gradients; elsewhere rock walls are built on the contour to form level benches. But at other places, in the absence of rock walls, we found a remarkable method used for adjusting cultivation to slopes: farmers dug up the bottom furrow of their fields that were laid out in contour strip crops and loaded the soil into carts, hauling it to the upper edges of the fields and dumping it along the upper contour furrows to compensate for down slope movement of soil under the action of plowing and the wash of rain. This was done each year. Where the slope was too steep to haul the soil up hill, we saw the farmers loading the soil of the bottom furrow in baskets and carrying it on their backs to the upper edges of the fields for the same purpose. In this manner do these farmers of France take care of their soil from generation to generation.

In southwestern France in the region of Les Landes we studied, probably, the greatest achievement of mankind in the reclamation of sand dunes. It is recorded that the Vandals in 407 A.D. swept through France and destroyed the settlements of the people who in times past had tapped pine trees of the Les Landes region and supplied resin to Rome. Vandal hordes razed the villages, dispersed the population, and set fire to the forests, destroying the cover of a vast sandy area. Prevailing winds from the west began the movement of sand, and in time moving and menacing sand dunes covered an area of more than 400,000 acres that in turn created 2,250,000 acres of marsh land. Sand dunes in their diabolic eastward march covered farms and villages and dammed streams causing marshes to form behind them. The scourge of malaria followed and practically depopulated the once well peopled and productive region. These conditions caused not only disease and death, but impoverishment of the people as well. In 1778 Villers was appointed by the French Government to create a military port at Arcachon. He reported that it was first necessary to conquer the movement of the sand dunes and presented the principle of "dune fixation." In 1786 Napoleon appointed his famous engineer, Brémontier, to control these dunes. Space will not permit telling the fascinating details of this remarkable story -- of how the dunes were conquered by the establishment of a litteral dune and reforestation of moving sand behind, and how marshy lands were drained by Chambrelent after a long period of experimentation and persuasion of public officials. Now this entire region is one vast forest supporting thriving timber and resin industries and numerous health resorts.

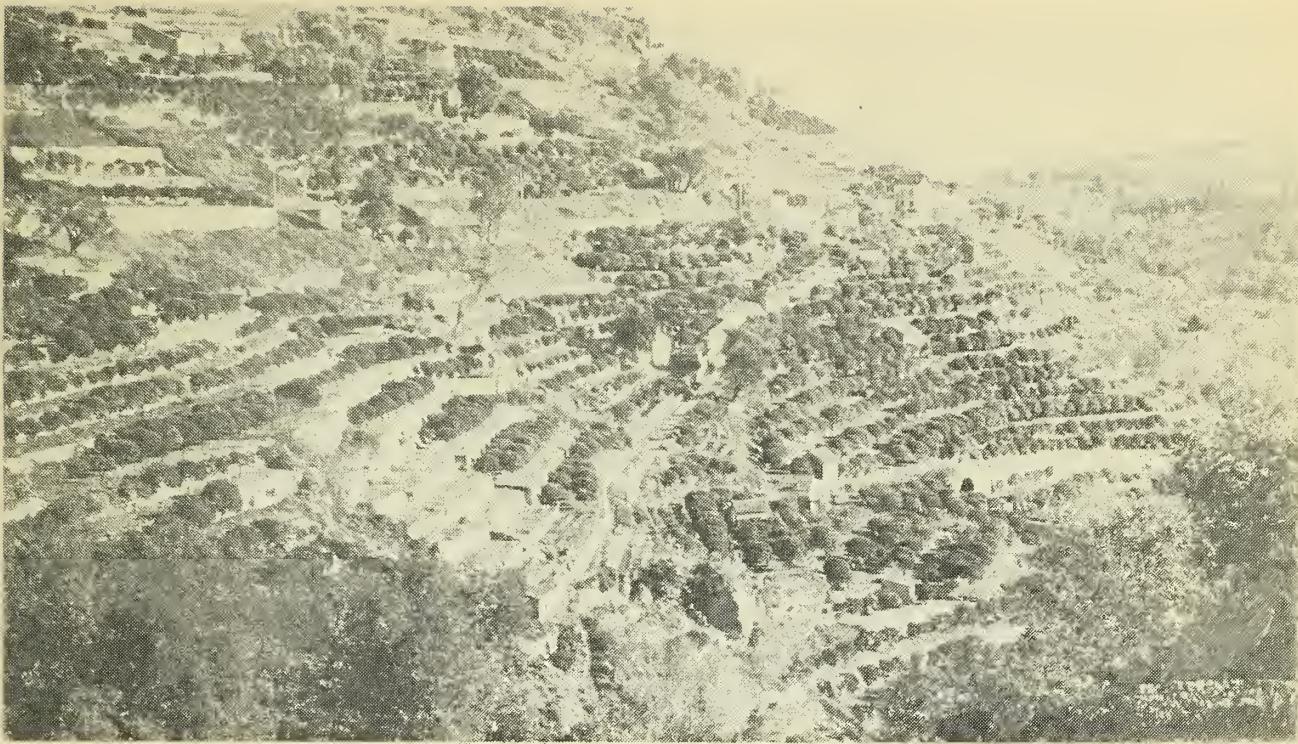


Fig. 13. A terraced citrus orchard in southern France. This land has been in cultivation for at least a thousand years and probably much longer than that; for it is believed that the terraces were first built by the Phoenicians more than 2,500 years ago.



Fig. 14. (L-83) Large sand dunes in southwestern France that are moving at the rate of about 60 feet each year. These dunes are literally engulfing the forest that may be seen at the base of the dunes.



Fig. 15. Contour strip cropping in southwestern Germany. Some farmers of Europe have been using this method to help control erosion for hundreds of years.



Fig. 16. (L-4) A view of productive farmland in Holland that was literally reclaimed from the sea. This land was on the floor of the sea only 7 years before this picture was made. The Dutch dyked off the sea and leached out the excess salt and minerals at a cost of about \$200 per acre.

Fortunately, for comparison, one dune on private land was for some reason left uncontrolled near Arcachon. This dune is 2 miles long, one-half mile wide and 300 feet high. It is now moving landward covering the forest at the rate of about 65 feet a year. As I stood on this dune, stung by the grains of sand in the teeth of strong winds off the sea, and looked to the north, to the east, and to the south, on an undulating sea of evergreen forest to the horizon, I began to appreciate the magnitude of the achievement of converting a vast menace of disease and death such as the giant sand dune underfoot and marsh lands behind into a saving resource of growing, profitable forests and health resorts. This is another example of adjustments of a people to land resources through land conservation.

#### How the Dutch Farm the Ocean Floor

We followed the westward course of civilization into Holland where we found another of mankind's greatest achievements -- the reclamation of the ocean floor for farming.

Holland is a land of about eight and a quarter million acres, divided into two almost equal parts -- above and below high tide level, and inhabited by eight million industrious people. Its land includes the great delta of the North Sea built up with the products of erosion sculptured out of the lands of Germany and Switzerland and northeastern France; brought down by the Rhine, and Meuse Rivers. Now 45 per cent of the area lies below high tide level and one-fourth lies below mean sea level. The Dutch from time immemorial have been carrying on an unending battle with the sea. They have become expert in filching land from the grasp of the angry waters of the North Sea.

The density of population of Holland per square mile of cultivated area is such that on the same basis the population of the United States would be one and a quarter billion people. This comparison, however, is unfair in some particulars for much of Holland is kept in permanent grass to support a thriving dairy industry. At any rate, the density of population of Holland has called for an increase of their land area. Rather than to seek additional land by conquest of their neighbors they have turned to the conquest of the sea. The Zuider Zee Project, two centuries in the planning, is their masterpiece in their two-thousand year battle with the North Sea. When completed, this project will add 550,000 acres of new land to Holland's territory and will convert the old salt Zuider Zee into a sweet water lake renamed the Yssel Meer.

The Dutch have built great dykes to dam off the sea and have pumped the water out of the basins with great pumping plants. They have dyked off the sea and de-watered the land, leached it of its salt, and converted it into productive farm land. We stood on fertile farmland that was the floor of the sea only 7 years earlier, that now is divided into farms equipped with fine houses and great barns. At a cost of about \$200 an acre, this land was reclaimed from the sea and divided into farms equipped with modern villages to supply all services for rural communities. The Dutch by this means have created a new agricultural paradise into which only select farmers may enter.

Laughingly, I told the manager of the Wieringermeer Polder that he was the St. Peter of this new agricultural heaven on earth. Out of 30 applications for each farm he selects one on the basis of his character, the past record of his family, and his freedom from debt. The successful applicant is put on probation for a period of 6 years and if he farms the land in accordance with the best interests of the land and of the country, he will be permitted to continue for another period. If he fails to do so, he must get off and give another farmer applicant a chance.

This thoroughly planned and perfectly executed project is without question the greatest achievement of mankind thus far in the reclamation of land for farm use. We do not know exactly how much this magnificent project was damaged by the invasion of Holland and partial flooding of the land during the recent war.

#### A Glance at England

As we follow the westward course of civilization into the mild climate of England, we find that tillers of soil here have had little difficulty with soil erosion, for rains come as mists and slopes are gentle and fields are usually farmed to close-growing crops of small grains. England is well suited to grassland farming and to the growing of small grains. Clean-tilled crops have never been in general use. So we found fields in England that have been cultivated for 1000 years or more where the yields of wheat have been raised to averages between 40 to 60 bushels per acre. The maximum yield thus far is 96 bushels to the acre. The principal problems before the farmers of England are rotations, seed selection and farm implements.

The recent war made new demands on the lands of England. Prior to blockading action by the enemy, the British Isles depended on imports for two-thirds of their total food supply. One-third of their population was fed from their own lands, requiring about 12 million acres of cultivated land for this purpose. In war time, fully 50 per cent more land was plowed to grow food crops; and most of it is still in cultivation. Pasture land and grassland on slopes are being cultivated. Soil erosion may become a problem more serious than ever before in British agriculture, because of the extraordinary demands for the growing of food.

#### The New World

And now we cross the Atlantic, following the course of civilization to the new land which by one of the most remarkable facts of history was kept for the most part isolated from the peoples of the Old World until civilization had advanced through a period of fully 6000 years.

The peoples found here, presumably descendants of tribes coming from Asia in the distant past, had been handicapped in the development of agriculture by lack of large animals suitable for domestication and by ignorance of the wheel or the use of iron. They had, however, learned to conserve water and soils in a notable way, especially in the terrace agriculture of Peru and Central America and in the Hopi country of Southwestern United States. Some have held that this knowledge was brought across the South

Pacific by way of islands, on many of which such practices are still found. In any case, lacking iron or even bronze tools, these peoples for the most part still depended largely on hunting, fishing and gathering along with shifting cultivation for their livelihood, and the soil resources seem to have been for the most part almost unimpaired.

To the peoples of the Old World, the Americas were a land of promise, a release from the oppressions, economic and political, brought on by congested populations and failures of peoples to find righteous adjustments to their long used land resources.

North America, as the first colonists entered it, was a vast area of good land, more bountiful in raw materials for a complex civilization than ever was vouchsafed any people. "The spacious Mississippi Valley is the most expansive habitation of mankind in the world," says the historian, Henry Truslow Adams. Its soils were fat with accumulated fertility of the ages; its mountains were full of mineral; its forests of timber; its clear rivers were teeming with fish. All these were abundant -- soil productivity, raw materials, and power for a remarkable civilization. How new is this land in comparison with the Holy Lands?

The hardy pioneers, who first settled the eastern seaboard and then the west, found a land beautiful for its rocks and rills, for its forests and valleys and for its majestic purple mountains; beautiful for its wide open plains and spacious skies; for the majesty of its scenery in lakes and snow-capped mountains. Our forefathers found a land wonderful for indescribable grandeur of scenery; wonderful for its great expanse as they continued the westward course of civilization to the shores of the Pacific.

Here was the last frontier of this westward march; for there are no more new continents to discover, to explore and to exploit. If we are to discover a way of establishing an enduring civilization we must do it here, for this is our last stand! We have not yet fully discovered this way; we are searching for the way and the light. Here is a challenge of the ages to old and young alike; a chance to solve this age-old problem of establishing an enduring civilization -- of finding a righteous adjustment of a people to its land resources.

Our land is like a great farm, plentiful for fields suited to the growing of cotton, corn, and other crops, plentiful in land for pastures, woods, and general farming. In the West, our country is plentiful for vast grazing lands well suited to the raising of herds of sheep and cattle, and plentiful for fertile alluvial valleys of the arid regions over-awed by high mountains that condense the waters out of moisture-laden winds to irrigate garden lands of high yields. Such is the American farm, plentiful for feeding at least 350 million people when the land is intensively cultivated under full conservation and fully occupied with a complex division of labor that will give us a higher general standard of living than we enjoy today.

### The Record of Our Lands

But now let us read the record that we have written on our own land in a very short period of 300 years.

In the past 150 years, our occupation of this fabulous land has coincided with the coming of the age of science and power-driven machines. By our understanding of a power over materials and forces of nature, we have been able to rip up the earth more rapidly than ever before in the history of the human race.

Along the Atlantic Coast in the Piedmont we find charming landscapes of fields with red soils and glowing grain fields, but lo! in their midst we find an insidious enemy devouring the land -- stealing it away, ere we are aware, by sheet erosion, rain by rain -- washing it down into the streams and out to the sea. Sheet erosion, marked by shallow but numberless rills in our fields, is blotted out by each plowing, so that we soon forget what is happening to the good earth until we measure these soil and water losses. More than 300 million acres out of our 400 odd millions of acres of farm fields are now eroding faster than soil is being formed. That means destruction of the land if erosion is not controlled.

We are not guessing, for erosion experiment stations located throughout the country in problem areas of soil wastage, have given us accurate results. Let us compare rates of erosion under different conditions of land coverage and use. Measurements through five years at the Statesville, North Carolina Erosion Experiment Station show that, on an 8 per cent slope, land in fallow without cropping lost each year an average of 29 per cent of rainfall in immediate runoff and 64 tons of soil per acre in wash-off of soil. This means that in 18 years, 7 inches of soil (the average depth of top soil) would be washed away to subsoil. Under continuous cropping to cotton, as was once the general practice in this region, the land lost each year an average of 10 per cent of rainfall and 22 tons of soil per year, which means that it would take 44 years to erode away 7 inches of soil. Rotations reduced but did not stop erosion, for the land lost 9 per cent of the rain and enough soil that it would take 109 years to erode away 7 inches of soil. That is a very short time in the life of our nation. But where the land was kept in grass, it lost less than one per cent of beneficial rain and a mere fraction of a ton of soil per year so that it would take 96,000 years to wash away 7 inches of soil; this rate is certainly no faster than soil is formed.

Under the natural cover of woods, burned over annually, as has unfortunately been the custom in southern woods, the land lost  $3\frac{1}{2}$  per cent of rain and six-tenths of a ton of soil per year, so that it would take 1800 years to erode away 7 inches of soil. But where fire was kept out of the woods, and forest litter accumulated on the forest floor, the land lost less than one-third of one per cent of the rainfall and an infinitesimal amount of soil, so that, according to the calculations, it would require more than 500,000 years to wash away 7 inches of soil. Such an infinitesimal rate of erosion is indeed far below the rate of soil formation.

Here in a nutshell, so to speak, we have the underlying hazard of civilization. By clearing and cultivating sloping lands -- for most of our lands are more or less sloping -- we expose soils to accelerated erosion by water or by wind and sometimes by both water and wind. In doing this we enter upon a regime of self-destructive agriculture. The direful results of this suicidal agriculture have in the past been escaped by migration to new lands or, where this was not feasible, by the most extraordinary works of terracing slopes with rock walls as was done in ancient Phoenicia, Peru, and China. Escape to new lands is no longer a way out. We are brought face to face today with the necessity of finding out how to establish permanent agriculture on our farms under cultivation before they are damaged beyond reclamation, and before the food supply of a growing population becomes deficient.

Within a new and underpopulated land such as is ours that is farmed extensively rather than intensively, there is considerable slack before privations on a national scale will overtake us. But privations of individual farm families, resulting from wastage of soil by erosion, are indicators of what will come to the nation as our population increases farm production goes down from depletion of soil resources, unless measures of soil conservation are put into effect throughout the length and breadth of the land.

We must be in possession of a certain amount of abundance to be provident, for a starving farmer will eat his seed grain; you will do it and I will do it, even though we know it to be fatal to next year's crop. Now is the time, while we still have much good land still capable of restoration to full or greater productivity, to carry through a full program of soil and water conservation. Such is necessary for building here a civilization that will not fall as have others whose ruins we have studied in this paper.

A solution to the problem of the farming of lands with more or less slope must be found if we are to establish an enduring agriculture in the United States. We have only about 100 million acres of flat alluvial lands where the erosion hazard is negligible out of 450 million acres of land that will ever be suitable for crops. Most of our production comes from sloping lands where the hazard of soil erosion is ever present, calling urgently for the discovery, adaptation, and application of measures for conserving our soils.

In the results of the Statesville Erosion Experiment Station we saw how a forest with its ground litter was effective in keeping down the rate of soil erosion well within rates of soil formation. Out of untold ages of unending reactions between forces of erosion that wear down the land and forces of plant growth that build up the land through vegetation, the layer of forest litter has proved to be the most effective natural agent in reducing surface wash of soil to a minimum. Here is clearly our objective for a permanent agriculture, namely, to safeguard the physical body of the soil resource and keep down erosion wastage under cultivation as nearly as possible to this geologic norm of erosion under natural vegetation.

A few years ago I came upon a hill farmer in an obscure part of the mountains of Georgia, who was trying to apply on his corn field the function of forest litter as he saw it under the nearby forest on the same slope and same type of soil. It was for me a great experience to sit down with J. Mack Gowder of Hall County, Georgia, in his forest beside the fields he had cultivated for 20 years in a way that has caught the imagination of thoughtful agriculturists of the nation. We talked about the simple device of forest ground litter and how effective it is in preventing soil erosion even on steep slopes, and how he thought that if litter at the ground surface would work in the forest it ought also to work on his cultivated fields just along the same slope.

Mr. Gowder told me how, as a young man when he bought this steep wooded land more than 20 years ago, he hoped to avoid the soil erosion that was ruining the farms on smoother and better land of the country. He planned to do this by stirring his land with deep plowing but without turning the soil, so as to leave his crop litter at the surface -- to do the same kind of work that the forest litter had done from time out of mind. Gowder chose a bull tongue plow, only 4 inches wide to do the trick. He told me that his neighbors laughed at him for such foolish ways of plowing. As a concession to customs of the region he put in channel terraces with a slight grade, as a precaution against storm runoff from unusual rains. But thus far they have not been needed. Now Gowder is cultivating topsoil on slopes up to 17 per cent whereas his ridiculing neighbors have only subsoil to farm, for they have lost all their topsoil by erosion.

Leaving crop litter which is sometimes called "stubble mulch" and "crop residue" at the ground surface in farming operations, is one of the most significant and important contributions to American agriculture and deserves to be spread wide through the country. Certain adaptations of the method need to be made to meet the problems of different farming regions, but the new principle is the contribution of importance. There is not time to go into variations of the Gowder crop litter method of farming, except to herald it as a discovery as important to agriculture of the New World and these times as the invention of the plow was to the Old World.

#### Danger Signs in America

Sheet erosion develops into gullies if allowed to continue unchecked for a few years. Such gullies become numberless gutters to lead off storm waters and flash floods that gouge out miniature gorges and ruin the land for further cultivation. Material washed out of such gullies is swept down into river valleys to shoal streams, to fill reservoirs, and to destroy water storage for hydro-electric power and for irrigation.

One of the most important findings of this survey of the use of land in 7000 years is that tillers of soil have encountered their greatest problem throughout the ages in trying to establish a permanent agriculture on sloping lands. We have read the record as written on the land, of failures from place to place but of few instances of success. This same problem is with us in our new land of America, where millions of acres have been destroyed for further cultivation and abandoned.

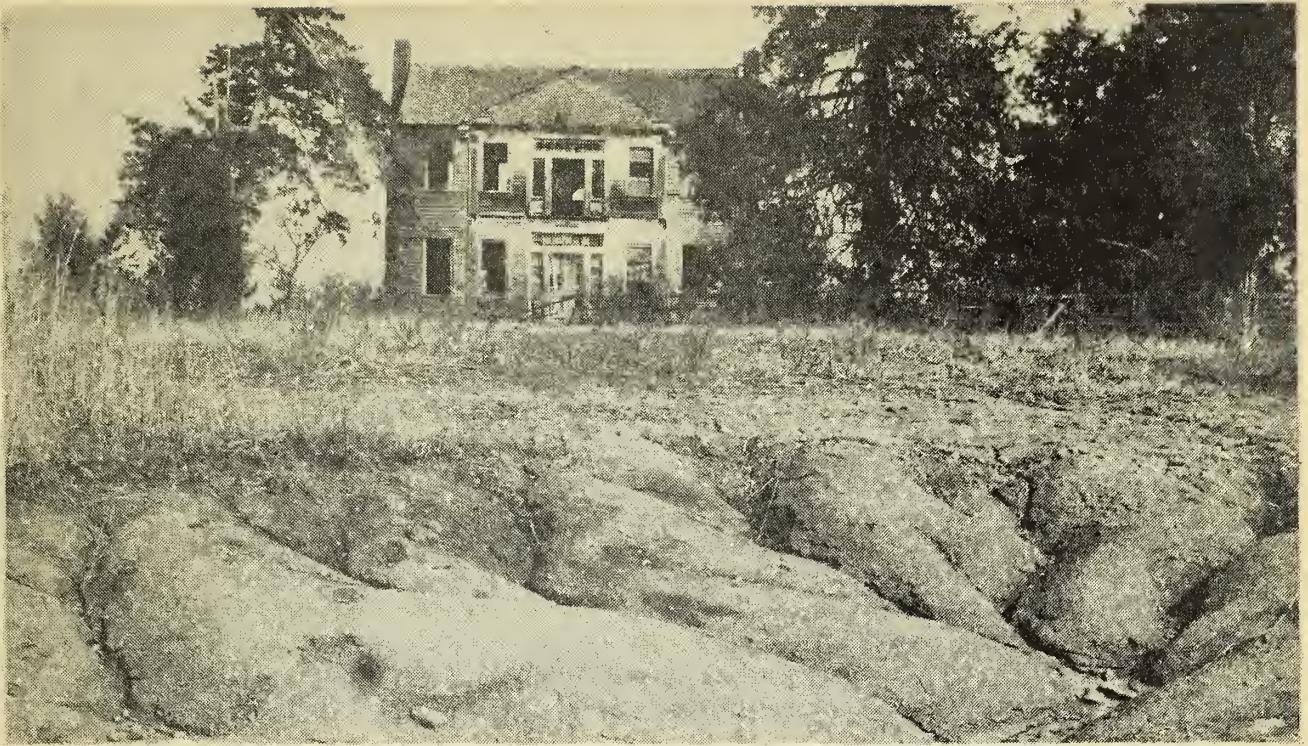


Fig. 17. This formerly fine American farm home has been abandoned for much the same reason that many cities of the old world were abandoned - the eroded land around it will no longer support a prosperous farm family.

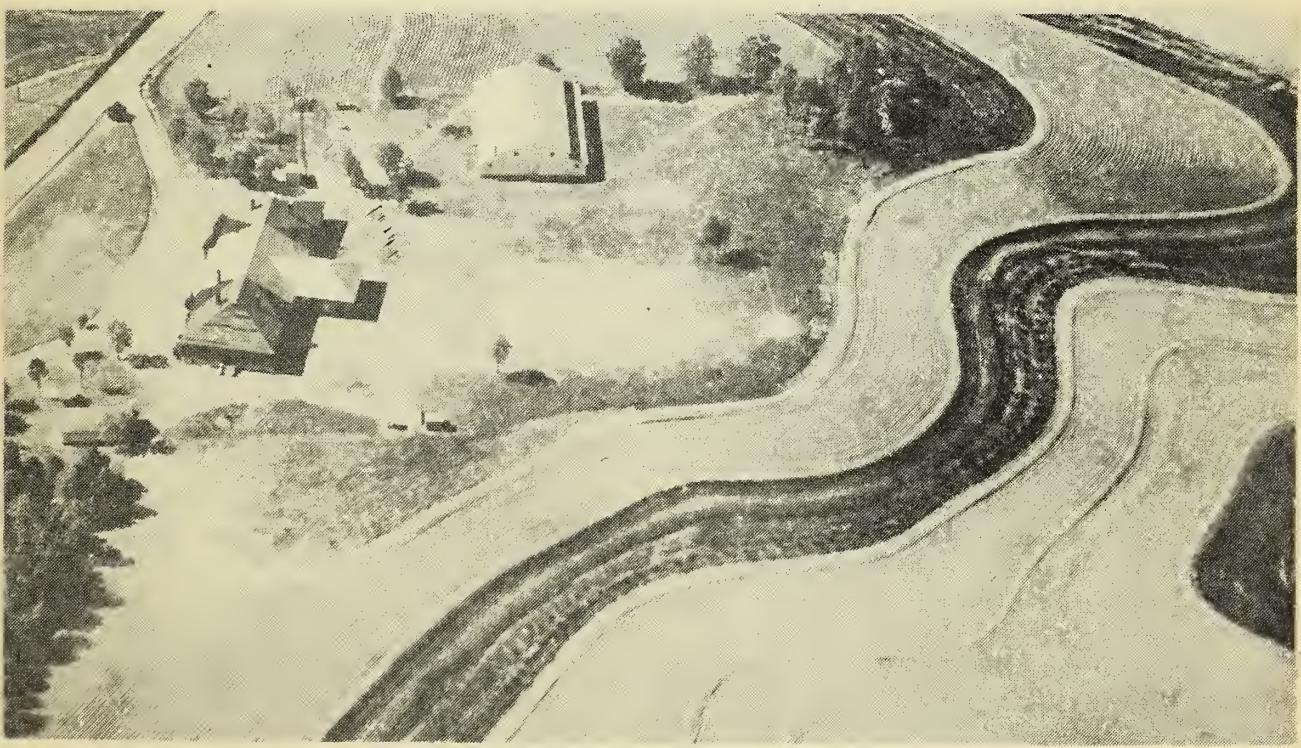


Fig. 18. This prosperous American farm is being farmed the conservation way. The terraces, strip crops, contour rows, and other soil and water conservation measures protect the land against erosion and help to build up soil fertility.

How then shall we continue to support fair cities and beautiful homes by agriculture on sloping lands of this country? Shall we resort to methods of ancient Phoenicia where slopes are terraced by building rock walls as a staircase to make lands level at an expense of \$2000 to \$5000 an acre? We say this is too costly even if we had the stone in place to build such terrace walls, but across our great land there is not enough stone within reach of eroding fields to terrace our land in this manner even if it were justifiable in cost. We must find some other solution to the age-old problem of slope cultivation.

### The Way to an Enduring Agriculture

We have a solution to this problem derived from the past experiences of farmers and from the results of experiments in our soil erosion experiment stations. This solution is contour farming supported by all other conservation measures. Our answer is contour farming, supported by necessary measures first to increase the intake capacity of the soil for rain waters by practices of retaining crop litter at the surface, soil improvement, crop rotations, and strip cropping on the contour; and second to lead away unabsoibed storm waters harmlessly in channels of broad base terraces into outlet channels and thence into natural drainage channels. By these coordinated measures applied and adapted to the land on a physiographic basis we have developed a new type of farming on the level rather than farming up and down the hill. This is our solution to reduce the rate of erosion to safeguard our soils on slopes where soil erosion by water is the hazard. We have applied this method, during recent years, over millions of acres as you may see from an airplane when you fly over portions of the country.

In Texas near Temple, in the drainage of North Elm Creek, 174 farmers of bordering farms joined themselves into a soil conservation association on a drainage basis covering a block of 34,000 acres. Control of erosion and of storm runoff was planned and carried out on a drainage basis, ignoring property and county lines in the same way as runoff water ignores such arbitrary lines. Terrace outlet channels were laid out to carry water harmlessly through one farm and another to natural drainage channels. One terrace outlet system may serve in this way as many as 5 farms. By this approach to conservation it is possible to treat the land in accord with its adaptabilities and to control storm waters according to hydraulic principles. This is indeed physiographic engineering that builds a lasting basis for a thriving civilization.

This does not mean that we have yet found the final answer to full control of soil erosion that will assure permanent agriculture, but we are on the way to that solution. Our present practices may not yet stop erosion, but will reduce it more and more as application of measures is more and more complete. These measures and others will need further improvement and adaptation to the problems as use of land becomes more and more intensive. Such is the way out to this age-old problem of establishing an enduring agriculture on sloping lands.

It is true that our level lands of the alluvial valleys have their problems of drainage both in the irrigated and rain supplied area. But these problems do not include the wastage of the physical body of the

soil resource. The soil remains in these flat lands, leaving us the freedom of choice of drainage when the lands are economically ripe for us. Our chief problem among many in the land conservation movement in the United States is to conserve lands under cultivation and grazing on slopes.

Wind erosion is a spectacular problem restricted to a smaller area of the country where it is, however, serious and destructive. Wind erosion attacks level as well as sloping lands cultivated in semi-humid and semi-arid parts of the country. Wind erosion sorts the soil more thoroughly than water erosion, lifting fine and fertile particles of soil aloft to be flown to "parts unknown," and leaving behind coarser and heavier particles that become sandy hummocks, then sand dunes that begin an inexorable march of destruction. Such was the case in the so-called "dust bowl" of the Great Plains.

Control of wind erosion is based first upon a suiting of the land to its capabilities, by conserving all or most all of the rain that falls on it, which calls for contour farming except on flat lands. Appropriate measures include strip shelter belts of crops, tillage practices that leave crop litter or residue at the surface, and rotations suited to moisture supplies in the soil profile. These with progressive improvement of soil management practices will control wind erosion. It has proved a simpler task, however, to control wind erosion than the less spectacular but more insidious water erosion.

#### Lessons from the Old World

In this discussion on lessons from the Old and New Worlds in conserving the vital heritage of our people, I have laid special emphasis on saving the physical body of soil resources rather than their fertility, for the following reason. Soil conservation must be a cooperative objective and undertaking. Maintenance of fertility is a part of this cooperative enterprise that falls properly to the farmer himself. Conserving the physical integrity of the soil resource falls to the nation as well as the farmer and landowner, in order to save the people's heritage and safeguard the national welfare. If the physical body of the soil resource is saved, we as a people are safeguarded in liberty of action, in applying more or less fertilizer, and of planting this or that crop in accord with market demands and national needs. If the soil is destroyed, then our liberty of choice and action are gone, condemning this and future generations to needless privations and dangers. So big is this job of saving our good lands from further damage and of reclaiming to some useful purpose vast areas of seriously damaged and ruined lands, that full cooperation of the individual interest of farmers with technical leadership and assistance of the Government is not only desirable, but necessary, if we are to succeed.

Another conclusion from our survey of the use of land through 7000 years where economic conditions have changed for better or for worse more rapidly than climate, is that land after all is not an economic commodity. It is an integral part of the nation even as its people are and requires protection by the individual owner and by the nation as well. Nowhere have we found more telling evidence of this truth than in California where

gold in '49 lured a host of people to the State, but soils of its valleys have maintained its settlement. It was said in times of old: "Thar's gold in them thar hills," but there was more than gold in the valleys. In the vicinity of Sacramento a few years ago when I examined this area, valley lands had a value of \$60 an acre for growing winter wheat with natural rainfall. But these lands overlaid gravels, and in these gravels was gold; so a dredging company boutht up the land, paying \$200 an acre for it. The company brought in mighty dredges to turn the land upside down to get out the gold and left these farming lands in windrows of quartzitic boulders that will not weather in a million years. What sort of economics is this: What shall it profit a nation if it gain a whole world of gold and lose its soil?

#### The Eleventh Commandment

When in Palestine in 1939, as I pondered the problems of the use of the land through the ages, I wondered if Moses, when he was inspired to deliver the Ten Commandments to the Israelites in the Desert to establish man's relationship to his Creator, and to his fellow men -- if Moses had foreseen what was to become of the Promised Land after 3000 years and what was to become of hundreds of millions of acres of once good lands such as I have seen in China, Korea, North Africa, the Near East and in our own fair land of America -- if Moses had foreseen what suicidal agriculture would do to the land of the Holy Earth, he might not have been inspired to deliver another Commandment to establish man's relation to the earth and to complete man's trinity of responsibilities to his Creator, to his fellow men and to the Holy Earth. When invited to broadcast a talk on soil conservation in Jerusalem in June, 1939, I gave for the first time what has been called the Eleventh Commandment, as follows:

THOU SHALT INHERIT THE HOLY EARTH AS A FAITHFUL STEWARD,  
CONSERVING ITS RESOURCES AND PRODUCTIVITY FROM GENERATION TO  
GENERATION. THOU SHALT SAFEGUARD THY FIELDS FROM SOIL EROSION,  
THY LIVING WATERS FROM DRYING UP, THY FORESTS FROM DESOLATION,  
AND PROTECT THY HILLS FROM OVERGRAZING BY THY HERDS, THAT THY  
DESCENDANTS MAY HAVE ABUNDANCE FOREVER. IF ANY SHALL FAIL IN  
THIS STEWARDSHIP OF THE LAND THY FRUITFUL FIELDS SHALL BECOME  
STERILE STONY GROUND AND WASTING GULLIES, AND THY DESCENDANTS  
SHALL DECREASE AND LIVE IN POVERTY OR PERISH FROM OFF THE FACE  
OF THE EARTH.

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Washington, D. C.  
August, 1942  
Revised slightly October, 1947

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